

REMARKS

Claim Rejections – 35 USC § 112, first paragraph

The examiner states that the disclosure is not enabling because, “It is not understood how the tilting of the rotor blades can be accomplished”. It appears the examiner is suggesting that the disclosure fails to teach one skilled in the art how to make the claimed rotor tiltable. The applicant traverses this rejection as discussed below.

It is believed that one skilled in the art of rotor design would be able to make and use the claimed invention as presently described and illustrated in the drawings. In the following discussion the applicant points to specific page/line numbers in the description that describe the ability of the blades/rotor to tilt, and also explains the well-known principles that a skilled helicopter designer would immediately recognize as enabling the blades/rotor as illustrated to tilt.

Firstly, there are no means to actively tilt the rotor blades or the rotor – and that is an important feature of the present invention. A helicopter utilizing this rotor is “passively stable in hover”, hence, the ability to tilt is built into the rotor as such. If the rotor tilts – this will happen due to aerodynamic forces acting on the rotor blades. When the lift created by the rotor blades is different in different parts of the rotor, anyone skilled in the art of rotor design will know that these differences in lift will try to tilt the whole rotor, and if the rotor is free to tilt it will eventually do so. As further described below, the application discloses means that would be immediately apparent to one skilled in the art of rotor design as allowing the rotor to so freely tilt. Any skilled rotor designer will also know that one way to create such differences in lift is that when the helicopter moves forward, then the advancing blade (the blade that rotates forward in the direction of flight) will experience higher air speed than the retreating blade. This difference in air speed gives a difference in lift that tilts the rotor. This indirect or “passive” way of tilting the rotor is described in detail on page 12, 13 and 14 (e.g. page 14, line 25 – 33) in the application.

The rotor as shown in the preferred embodiment illustrated in Fig 1 is free to tilt by the combination of two characteristics. First, as shown in the figure, each set of rotor blades is connected to the rotor shaft by a hinge. This hinge, however, only permits tilting in one direction.

(This is, in fact, a feature that permits the unique stability of the rotor as discussed elsewhere in this reply and in the application.) The result is that, in order for the rotor to be freely tiltable, the blades must be flexible so that the blades will twist when they are not in the position whereby the hinge-direction allows the tilting. As stated at page 11, line 2:

Because each set of rotor blades are able to tilt independently [i.e. via its hinge] and because all of the rotor blades are able to twist [i.e. via the choice of materials, cross sectional shape etc] this in combination enables the rotor (10) and the rotating plane (A) to tilt in any direction with respect to the reference plane (B). Any tilted orientation of the rotating plane (A) will thus comprise a combination of tilted and twisted blades, including blades that are both tilted and twisted at the same time.

The rotor in the alternative embodiment shown in Fig 4 is free to tilt by virtue of the blades being connected to a hub that is connected to the rotor shaft by gimbals.

To allow any helicopter rotor to tilt, the rotor blades are normally connected to the rotor shaft by flexible or pivoting hinges. Different technical solutions utilizing such hinges in order to enable a rotor to tilt are well known to anyone skilled in the art of rotor design. In the preferred embodiment, the hinges referred to on page 10, line 6 to 8 as “any kind of hinge, either consisting of pivoting pins or some kind of flexible material” are further described on page 10, line 8 to 20. The details of the rotor are also clearly shown in figure 1, 2, 3 and 5 in the application. There are no special requirements for the hinges apart from what is described in the application and it is fair to believe that a skilled rotor designer would immediately recognize what is meant by “pivoting pins” or “flexible material” and know how to design and build this – including what kind of materials to use in order to get the required strength and durability. A skilled rotor designer would typically use pivoting pins made of hardened steel resting in a boss made of a durable softer material like i.e. nylon for a model sized rotor or he would use ball bearings for larger rotors.

The 4-bladed rotor of the preferred embodiment of the present invention has two orthogonally oriented pairs of rotor blades where both pairs are tiltably connected (hinged) to the rotor shaft and furthermore fixed to a ring encircling the rotor. Because the blade pairs are orthogonally oriented and also fixed to the ring each rotor blade must be able to twist in the longitudinal direction to

enable the rotor to tilt. This is described in detail in the application on page 10, line 21 to page 11, line 9. To enable the rotor to tilt, the rotor blades must be able to twist in the longitudinal direction. One of the tasks a skilled rotor designer normally has to address is making the rotor blades as stiff as possible in order for them not to twist. It is fair to believe that a skilled rotor designer that knows how to make a stiff blade also would know how to do the opposite, i.e. to build a rotor blade that twists easily but does not bend. It is believed to be obvious to anyone skilled in the art to choose an open airfoil "having the shape of a thin curved plate". To use such an airfoil is described on page 9, line 9 to 15.

In addition to being able to tilt in any direction the rotor described in claim 1 also has rotor blades wherein one part has a pitch angle generally fixed to the rotational plane (i.e. the tip at the ring) and one part has a pitch angle generally fixed to the reference plane (i.e. the inner part of the blade that has an angle fixed relative to the plane perpendicular to the shaft). How this is accommodated by the rotor in the preferred embodiment will immediately be recognized by a skilled rotor designer by looking at the figures and by the discussion above and on page 11, line 10 to 21 in the application.

Almost any material commonly used in helicopters and airplanes may be used to build a rotor according to the present invention and materials like plastic sheets, aluminium, injection molded plastic, glass fiber and carbon fiber composites may be used. On page 18, line 25 to 26 using carbon fiber or a similar material is suggested. It is well inside the skills of a rotor designer to use such materials and understand how to utilize the material properties in order to obtain the features described in the application. It is furthermore described factors that the skilled designer should take into account when designing and building the rotor. Factors like the coning, the weight of the blades and the ring as well as the rotational speed of the rotor are discussed on page 15. These factors are well known to a skilled rotor designer as they are the same factors he will have to optimize in a standard rotor. It is fair to believe that he would recognize the need for e.g. wider blades and a heavier ring if the rotational speed is low as described on page 15, line 19 to 22.

The application also describes an alternative rotor with rotor blades consisting of two elements flexible or hinged connected. Based on the drawing in figure 4 and on the descriptions on page 16, line 12 to page 17, line 6 it will be immediately recognized by a designer skilled in the art that the

techniques and materials needed to build this rotor is essentially the same techniques and materials used in traditional helicopter rotors and airplane wings. The rotor blades will here have to be as stiff as possible – like in traditional rotor blades. Hinges as well as gimbals and link arms are very well known from the early days of helicopter design. The details that a designer should pay attention to with respect to e.g. hinge lines and the position of link arms are described on page 17, line 7 to 22.

Based upon the foregoing, it is respectfully believed that the claims as written are enabled by the disclosure.

Claim Rejections – 35 USC § 112, second paragraph

The examiner appears to suggest that the claims are indefinite because it is not possible to build a rotor according to claim 1 with less than 4 rotor blades. This is not correct.

If the rotor blades are comprised of two or more elements hinged together (ref. claim 6) it is possible to build both a 2- bladed and a 3-bladed rotor. This is described on page 16 and 17 (i.e. page 17, line 30) in the present application and shown in figure 4.

It is also possible (however not very practical) to build a rotor according to the preferred embodiment in the present application but completely omitting one of the blade pairs, hence leaving the rotor with just two rotor blades and the ring. Such a rotor works and it is stable however it is more fragile and easier damaged than the 4-bladed version. This way of using just two blades is not described in the present application, but it is possible to do and it works. As discussed at page 11, line 8 the blades may be both tilted and twisted at the same time, thus permitting a single blade-pair to exhibit the characteristics of the claim.

On this background it is appropriate that claim 1 read: “A rotor, generating lift, at least comprising **two** rotor blades”. If “two” was changed to e.g. “four” the applicant would immediately loose much of the intended scope of protection. In such a case it would be possible for anyone skilled in the art to build a rotor according to the present invention that arguably would not literally infringe such a worded claim.

Further the examiner objects to the use of the term “at least comprising” in claim 1, the claim reading: “A rotor, generating lift, **at least comprising** two rotor blades and....”. As discussed above, the applicant respectfully believes that the use of this term properly covers the intention of claiming 2 or more rotor blades. If, however, the examiner is primarily concerned with the relative placement of the expression “at least”, the applicant has now amendment claim 1, changing “at least comprising two rotor blades and...” to read instead, “comprising at least two rotor blades and...”

With respect to claim 14 being objected to because of multiple dependent claim 8, the applicant has amended claim 14 into a single dependent claim.

Claim Rejections – 35 USC § 102

Because all the dependent claims (all remaining claims except claim 1) in the present application should be accepted as novel and non-obvious if the independent claim 1 is so found, the following discussion will primarily focus on the novelty and non-obviousness of claim 1.

In US 4,092,084, Barltrop discloses a rotor for an autogiro (not a helicopter) that automatically increases the pitch angles of the rotor blades when the load, and thereby the coning, of the rotor increases. For a given coning at a given point in time the Barltrop rotor and the prior art rotor shown in figure 1, 2 and 3 in his patent functions like well known traditional fixed pitch teetering rotors similar to those mentioned in patent US 6,460,802 and used in the early Kaman helicopters, both relied upon (page 1 and 2) in the present application.

The rotor in the present application enables an aircraft to become aerodynamically stable in hover. The novel and innovative steps to achieve this is not to have the different features of the rotor acting separately, but rather the combination of these features acting together in the same rotor. Some of these features act against each other and some result in behaviour not wanted in traditional full scale helicopters. E.g. the rotor’s increased ability to tilt up in response to any horizontal movement is something that helicopter designers normally work hard to avoid and

instead they try to achieve exactly the opposite of this. These features and how they work together are described in detail on page 11, 12, 13, 14 and 15 in the present application. Not one of the rotors in the documents mentioned by the examiner, and no other rotors known to the inventor utilize the same combination of features or have the same ability to achieve passively aerodynamic stable flight without relying mainly on gyroscopic effects.

A 2-bladed fixed pitch teetering rotor (as disclosed in Barltrop) has these characteristic features:

- The rotational plane can tilt freely with respect to a reference plane perpendicular to the rotor shaft axis.
- The pitch angle of the rotor blades are generally fixed with respect to the reference plane.
- NO part of any of the rotor blades has a pitch angle that is fixed or generally fixed with respect to the rotational plane when the rotational plane is tilted with respect to the reference plane. (Please see the discussion below.)
- The rotor is relatively stable with respect to the rotor shaft; however, an aircraft utilizing such rotors, including coaxial contra rotating rotors, is not in any way passively stable.

Even though the examiner states that the Barltrop rotor has blade tips with pitch angles fixed relative to the rotating plane, this is NOT true. If we examine the pitch angles of the rotor blades in the Barltrop rotor (at a given load and coning) in a situation where the rotor shaft is vertical and the rotational plane is tilted with respect to the reference plane, it can easily be appreciated that the blade pitch angle at the low point and at the high point is unchanged with respect to both the rotating plane and the reference plane. However, when the rotor rotates and the low blade starts to tilt up and the high blade starts to tilt down this is changed. After rotating 90 degrees, at the middle point between the low and high points, the rotor blades are generally horizontal but they still have retained their original pitch angle as can clearly be seen. The pitch angles of the rotor blades remain generally fixed with respect to the vertical rotor shaft and the reference plane and not to the tilted rotational plane. At this point of the rotation (rotor blades generally level), the tilted rotating plane has its maximum and minimum angles with respect to the rotor blades. When we have a tilted rotating plane the pitch angles are NOT fixed relative to the rotational plane, only to the reference plane. The pitch angles with respect to the rotational plane will vary above and below the original angle as the rotor rotates.

This angular relationship is similar to the inner part of the flexible blades shown in the preferred embodiment of the present invention, i.e. the part that has a fixed pitch angle with respect to the reference plane. The blades of the preferred embodiment, however, have a second part, i.e. the tips, that are forced to twist such that the tips have a pitch angle that is fixed relative to the plane of rotation. The tips of the blades from Barltrop are not forced to twist such that they remain at a fixed pitch angle with respect to the plane of rotation. The tips of the Barltrop blades have the same pitch angle as their inner part. The fact that the tips of the Barltrop blades may randomly and to a small extent twist a little does not imply that the tips have a fixed pitch angle with respect to the rotational plane.

The examiner claims that the rotor blades of Barltrop may twist during their rotation because they are flexible. This twisting however, is relatively small, especially on a fixed pitch teetering rotor (as discussed above) and it is an entirely un-wanted effect that the designers try to avoid. Normally all rotor designers try to make the blades twist as little as possible. The feature of having a rotor: “wherein at least one of the rotor blades are made of a flexible material enabling said rotor blade to twist in a longitudinal direction” is not mentioned, anticipated or foreseen by Barltrop. On this background it is fair to say that the rotor described in claim 3 of the present application is both novel and nonobvious.

The rotor described in claim 1 and shown e.g. in figure 5 of the present invention has the following combination of characteristic features:

- the rotating plane (A) is tiltable in any direction with respect to a reference plane (B) perpendicular to the rotor shaft (18) axis,
- at least a part of one or more of the rotor blades (11) [i.e the inner part] has a pitch angle (41) generally fixed relative to said reference plane (B),
- at least a part of one or more of the rotor blades (11) [i.e. the tips] has a pitch angle (42) generally fixed relative to the rotating plane (A).

A 2-bladed fixed pitch teetering rotor (as discussed above) has only 2 of these characteristic features. Typically rotors do not have the feature that “at least a part of one or more of the rotor blades has a pitch angle generally fixed relative to the rotating plane”. The combination of all of these three features is new and unique and has never been either anticipated or foreseen, by

Barltrop or others. This feature in combination with the two other features is what enables the rotor of the present invention to function and behave differently from all other known rotors.

The Barltrop rotor furthermore has a feature that increases the pitch angles of the rotor blades when the load, hence the coning, increases. In fact this is the main feature of the Barltrop rotor and with this feature even the fixed pitch angles of the rotor blades with respect to the reference plane are not fixed anymore. As can then clearly be seen; the rotor's ability to tilt is the only feature it has in common with the rotors described in the present application.

Furthermore:

- None of the references mentioned by the examiner addresses the same technical problem as in the present invention.
- None of the references mentioned by the examiner and no other rotors known to the inventor behave dynamically and aerodynamically as the rotor in the present invention.
- None of the references mentioned by the examiner and no other document known to the inventor indicates, predicts or foresees the combination of features used in the present invention.

On this background it is fair to say that the rotor described in claim 1 of the present application is not anticipated by Barltrop.

Claim Rejections – 35 USC § 103

Above, it is argued why claim 1 is believed novel over Barltrop. The examiner states that the features of the present invention are anticipated if you combine the rotors from Barltrop and Meek. However, none of these patents mention the feature that: “at least a part of one or more of the rotor blades has a pitch angle generally fixed relative to the rotating plane”, nor do they give any indication or reference to a function or to rotor behavior requiring such a feature. Since they do not describe or foresee the three main features of the present invention, any combination with other features like i.e. a conical geometry must still be regarded as novel. Meek has at best a pictorial relationship to the current invention, and combining the ring from Meek with the rotor from

Barltrop will still not result in a blade having a pitch angle fixed in relation to the plane of rotation. Even if a ring were attached to the blades from Barltrop, the blades would not be forced to twist at certain parts of the rotation such that the tips retain a fixed pitch angle with respect to the plane of rotation.

With reference to claim 6 where a rotor blade is made of two or more elements it is fair to point out that none of the documents cited by the examiner discloses the following combination of characteristic features described in claim 1 of the present application:

- the rotating plane (A) is tiltable in any direction with respect to a reference plane (B) perpendicular to the rotor shaft (18) axis,
- at least a part of one or more of the rotor blades (11) has a pitch angle (41) generally fixed relative to said reference plane (B),
- at least a part of one or more of the rotor blades (11) has a pitch angle (42) generally fixed relative to the rotating plane (A).

Even if blades made of two or more elements are well known, the combination with the features mentioned above has never been disclosed before. Since the cited documents do not describe or foresee the three main features of the present invention, any combination with other features like i.e. rotor blades made of two or more elements must still be regarded as novel and nonobvious.

JP 52-88998 discloses a small vertical rotor in the rear of a helicopter. As the examiner points out using a small rotor like this to create a more maneuverable system is well known. In claim 10 of the present application this feature is described in combination with a rotor having the following combination of characteristic features described in claim 1 of the present application:

- the rotating plane (A) is tiltable in any direction with respect to a reference plane (B) perpendicular to the rotor shaft (18) axis,
- at least a part of one or more of the rotor blades (11) has a pitch angle (41) generally fixed relative to said reference plane (B),
- at least a part of one or more of the rotor blades (11) has a pitch angle (42) generally fixed relative to the rotating plane (A).

Even if using a horizontal tail rotor is well known, the combination with the features mentioned above has never been disclosed before. Since the combination of documents cited by the examiner

do not describe or foresee the three main features of the present invention, any combination with other features like i.e. a horizontal tail rotor must still be regarded as novel and nonobvious.

CONCLUSION

For the forgoing reasons, the claims of the application are believed to be enabled, definite, novel and nonobvious. Favorable reconsideration is therefore solicited.